

Task 6: Dynamic Comprehension: Time on Position and Mental Fatigue (Bailey)

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Requirements Statement

Operational Shortfall or Knowledge Gap

The ATO needs to know how controllers develop and maintain dynamic comprehension of air traffic situations. Because the results of FY09 research demonstrated that technology was not sufficiently advanced to be able to reliably measure changes in dynamic comprehension on the order of seconds (which was a requirement for this research), the requirements statement is being changed to address the second benefit (see below), which is to inform the ATO about the maximum amount of time a controller can be on position before experiencing degradation in cognitive performance sufficient to affect air traffic control performance. This research is in line with what is commonly referred to in the fatigue literature as “time on task fatigue.”

Benefit in Closing the Shortfall or Gap

The ATO needs to know how long it takes a controller to develop dynamic comprehension (often called Situation Awareness) after taking over a position in today’s environment. Furthermore, the ATO needs to know how long a controller can maintain dynamic comprehension before suffering degradation in his/her ability to monitor and/or control traffic. This is in line with the NextGen requirement to increase controller efficiency.

Description of the Desired Product

Provide recommendations for improving dynamic comprehension following a position transfer and for maintaining dynamic comprehension after being on position in excess of 1 hour and 30 minutes. FY09 results produced recommendations for improving dynamic comprehension following a position transfer. However, those recommendations were constrained by the lack of reliability in the measures used track dynamic comprehension.

Given the shift in emphasis from measuring shorter term cognitive decrements (on the order of seconds) to longer term decrements associated with time on task fatigue, the following products are desired: Provide estimates for the maximum amount of time a controller may be on position before experiencing cognitive decrements sufficient to affect controller performance and the length and type of break activities necessary for controllers to fully recover from time on task fatigue.

Schedule

The original schedule was from FY08 through the end of FY10. This is extended to FY11 to accommodate the need for determining time and type of break activities necessary to recover from time on task fatigue. This will require a FY11 experiment with contracted controllers and or controller students from Oklahoma University's College Training Initiative. FY11 outputs refer to activities 4 and 5 (under Objective 3) below.

Research Objective

There are three research objectives: (1) Identify measures sensitive to changes in dynamic comprehension that occur following a position transfer, (2) Determine the minimum amount of time on position that a controller needs to develop dynamic comprehension, and (3) Determine the maximum amount of time a controller can work on position before suffering a degradation in dynamic comprehension. All objectives will be accomplished within a simulated en route air traffic control environment.

Objectives 1 and 2 were accomplished and reported in the end of year report for FY09.

Objective 3 has been expanded to include the following: (1) Identify physiological markers of time on task fatigue, (2) Identify cognitive decrements associated with time on task fatigue while performing air traffic control activities, (3) Identify maximum time a controller can be on position before experiencing decrements in cognitive performance that impacts CPCs' operational performance, (4) Determine break duration necessary to recover from time on task fatigue, and (5) Identify break activities that may impede or enhance time on task recovery.

Background

An operational error (OE) occurs whenever separation minima between aircraft are compromised as a result of a controller's actions or inactions. Recently Schroeder, Bailey, Manning, and Pounds (2006) conducted a review of the available literature on the human causal factors associated with air traffic control (ATC) OEs and mitigation strategies that have been implemented over the past 45 years, between 1960 and 2004. One of the findings of the literature review was that a relatively high percentage of OEs occurred during the first 10 minutes on position and that the relationship was consistent across options (e.g., en route, terminal approach control, and tower), years, and time of day. Furthermore, there was a substantial drop in the percentages of OEs that occurred after 50 minutes on position. The authors speculated that this drop-off may be due to the fact that few en route controllers remain on position longer than 50 minutes.

Past OE reduction initiatives focused on changing the position relief briefing (PRB), which occurs during the transfer of position responsibility, as a means of reducing OEs that occurred early on position. However, there was little empirical evidence to document the extent to which an inadequate PRB played a prominent factor in OEs that occurred early on position. One reason for the lack of evidence may be due to the nature of the position relief process. Much of what

occurs during the transfer of position is mental, and thus, is not subject to direct observation. In particular, it is not possible to directly observe whether a relieving controller has developed sufficient dynamic comprehension prior to assuming position control. Anecdotal evidence suggests that controllers are still developing dynamic comprehension after assuming position control and do not fully comprehend the dynamic characteristics of the traffic flow until after they have interacted with each aircraft under their control. Thus, there appears to be a period of vulnerability to dynamic comprehension following a position transfer, even though we have not yet measured it. In a similar fashion, the concept of having controllers serve as system monitors may create a period of vulnerability when the controller switches from the role of a passive system monitor to the role of issuing positive control commands. During the switch, a period of time will occur when the controller is developing his/her comprehension of the dynamic traffic situation before deciding on the best course of action to resolve any traffic conflicts.

Given that the traffic situation is dynamic, controllers on position continually update their dynamic comprehension by gathering information while scanning the radar screen. Assuming that the complexity of the traffic situation is within the parameters of a controller's abilities, there comes a time when mental fatigue settles in and a controller needs to be relieved. Although the current labor contract restricts the amount of time a controller can remain on position to 2 hours (except in special circumstances), this limit does not appear to be based on empirical data. That is, we do not know how long controllers can stay on position (and under what conditions) before suffering degradation in their dynamic comprehension.

Additional support for pursuing research on mental fatigue comes for the National Transportation Board's (NTSB) Most Wanted Transportation Safety Improvements List. The NTSB called on the FAA to:

1. Set working hour limits for flight crews, aviation mechanics, and air traffic controllers based on fatigue research, circadian rhythms, and sleep and rest requirements.
2. Develop a fatigue awareness and countermeasures training program for controllers (NTSB, 2008).

A review of the existing literature on controller fatigue shows that the FAA has almost exclusively focused on empirically measuring and developing countermeasures for shift work fatigue. Research on time on task fatigue (as a result of mental fatigue) is lacking. Thus, this research, while operating independently from the ATO's current research in controller fatigue, nevertheless speaks to the broader issue of controller fatigue.

Previous Activity on this Task

During FY08, research was conducted to identify measures that would be sensitive to changes in dynamic comprehension on the order of 2 minutes or less. Two measures were identified from the literature and an experiment was conducted to validate their effectiveness: (1) Situation Present Assessment Method (SPAM), and (2) Oculomotor measurements. Although the SPAM analyses demonstrate its utility, analyses of the Oculomotor data were delayed due to the declination by the FAA Grants Office of a cooperative agreement between CAMI and Washington University in St. Louis.

During FY09, it was discovered through a contract with Bio Behavior Analysis Systems that oculomotor measurements, while reliable, do not produce unambiguous results. To produce valid results, the measures needed to be calibrated against a “gold standard,” However no such standard exists for measuring dynamic comprehension. SPAM measurements, although useful for a summative measure of controller SA, were not sensitive to changes in dynamic comprehension on the order of seconds.

Both of the above findings were discovered during the first experiment of Study 1. Based on these results, Experiment 3 of Study 1 was modified (per the direction of AJP-61) to address information processing vulnerabilities early on position. Two research questions guided this effort:

- Q1: Do controllers have a complete mental representation of what is on the radar screen at the time of assuming position control?
- Q2: Are controller’s expectations about what they plan to do consistent with their actual performance once they assume position control?

The results of Experiment 3 of Study 1 were presented at the October 2009 TCRG meeting and included the following findings:

Memory and Plans

Participants did not commit to memory what would be available on the radar screen. This suggests that memory is constantly being updated based on the dynamic characteristics of the sector.

Participants knew which aircraft they had to “worry” about. Other than that, their plans unfolded as they “worked” the traffic.

This suggests that participants lacked conscious awareness of the amount of time necessary to interact with aircraft.

Recommendations

Minimum Time on Position

Between 5-10 seconds per aircraft based on the information processing necessary for the self-briefing.

Using the MAP value (18 aircraft) for this sector, this would translate to between 1.5 and 3 minutes. The MAP value (Monitor Alert Parameter) is a numerical value that is used as a trigger to alert traffic management that congestion within a sector may affect traffic flow down the line.

The more uncertainty due to weather and/or conflicts, the longer it takes for a controller on position to have an experiential (i.e., “hands-on”) understanding of the traffic situation.

Human Factors Training for Controllers

Need to know transfer of position vulnerabilities associated with memory, and planning and decision making.

Experiments suggest that controllers underestimate the amount of time they need and over-estimate how much they know about what is on the radar screen.

Human Factors Training for Supervisors

Need to know transfer of position vulnerabilities associated with memory, and planning and decision making.

Be wary of allowing position transfers of 5 minutes or less.

During FY10 a change occurred in the start time for the second experiment of Study 2. The start time was delayed one month due to delays in awarding the contract that will be used to collect and analyze EEG data. All subsequent milestones were adjusted to account for the one month delay in start time. The delay was associated with changes in contracting policies that were not communicated to the PI until two months after the statement of work had been submitted. The changes necessitated a complete reworking of the contract submission.

Proposed or Planned Research

SPAM and oculomotor measurements will be used to track changes in dynamic comprehension that occur during the first 10 minutes a controller is on position. EEG measurements will be added to the measurement toolbox to assess changes in dynamic comprehension associated with controllers working longer than 1.5 hours on position. All performance measurements will be collected using the Air Traffic Control Advance Research Simulator (ATCARs) with standardized air traffic control scenarios.

Study 2 will take advantage of a research contract with Oklahoma University's Department of Electrical Engineering Computational Imaging Laboratory to collect EEG recordings from college students trained in performing air traffic control tasks similar to those used in the Air Traffic Control Scenario Test that forms a basis for selecting air traffic control candidates. If Study 2 proves to be successful, a more comprehensive Study 3 may be conducted in ATCARs and/or Oklahoma University's Department of Aviation en route simulator that is used to conduct air traffic control classes as part of the College Training Initiative.

Research Question(s)

1. Are there measures that can detect changes in dynamic comprehension on the order of 2 minutes or less?
2. What changes in dynamic comprehension are experienced by controllers who assume position control under varying workload conditions?
3. What changes in dynamic comprehension are experienced by controllers who exceed the maximum amount of time a controller is allowed to remain on position according to the current labor agreement?

As previously reported, the first 2 questions were addressed by Study 1. The questions guiding Study 2 were revised to include the following:

3. What cognitive decrements are experienced by controllers who are experiencing time on task fatigue?
4. How do the break duration and type of break activities affect time on task fatigue recovery?

Technical Approach

Current Year

An experimental approach will be used to determine the amount of time it takes to develop dynamic comprehension following a position transfer under varying workload conditions.

Out-Years

An experimental approach will be used to identify the maximum amount of time a controller can be on position before experiencing degradation in cognitive performance sufficient to affect air traffic control performance under varying workload conditions.

The 2010 program is designed to identify EEG markers of mental fatigue

The 2011 program is designed to determine length of break and type of break activities necessary to recover from mental fatigue.

Air Traffic Resources Required

None, unless sponsors request the use of active certified professional controllers as participants. Otherwise, contract instructors and/or CTI students will serve as research participants.

Calibration

None required.

FY10 Milestone Schedule		
Description	Proposed Start Date	Proposed Completion Date
Study 2 - Dynamic Comprehension Later on Position Experiment 1 Sensitivity of Measures * Conduct experiment to demonstrate the sensitivity of EEG measures to detect the presence of mental fatigue associated with performing air traffic control tasks for 2 hours without a break.	October 1, 2009	December 31, 2009 COMPLETED
Experiment 1 – Analysis * Analyze EEG results	January 1, 2010	June 30, 2010
Experiment 2 – Dynamic Comprehension and Mental Fatigue * Conduct experiment to measure the type of and quantity of the decline in cognitive performance experienced by participants who were performing air traffic control tasks for 2 hours without a break.	August 1, 2010	October 31, 2010
Experiment 2- Analysis * Analyze EEG and Cognitive Assessment results	November 1, 2010	April 30, 2011
Study 3 – Recovery from Mental Fatigue * Conduct experiment to determine length of break and type of break activities necessary to recover from mental fatigue. It is likely that this experiment will be adjusted based on recommendations of the Article 55 Working Group – Controller Fatigue Risk Management System	May 1, 2011	September 30, 2011

FY10 Deliverables		
Description	Proposed completion date	Actual completion date
Sponsor Briefings <ul style="list-style-type: none"> * Study 1- Dynamic Comprehension Early on Position * Results of Experiment 1 * Results of Experiment 2 * Results of Experiment 3 * Study 2 - Dynamic Comprehension Later on Position * Results of Experiment 1 * Results of Experiment 2 	1QFY09 2QFY09 4QFY09 4QFY10 2QFY11	11/19/08 4/20/09 9/30/09
OAM Technical Reports <ul style="list-style-type: none"> * Study 1 - Dynamic Comprehension Early on Position: Draft 	3QFY10	COMPLETED
Supporting materials will be provided at the request of the AJP-61 Program Management. These include power point charts and briefing slides for TCRG meetings, abstracts for reports that don't already include them, quarterly reports, and text for the annual report summarizing the year's activities.	As needed	